

occupation, an occupation that places them on a level with the turnspit. It is one which is most properly meted out in our prisons as a punishment for crime, accompanied, however, with the degradation that the force exerted shall be entirely wasted in idly turning a fan in the free air, and thus the prisoner, in addition to the fatigue of his body, undergoes the humiliation of, as he expresses it, "grinding the wind."

If they played no other part than that of relieving humanity from such tasks as these, prime movers would be machines to be hailed.

True it is that the labourers who were thus relieved would not thank their benefactors, and indeed so far as the individuals subjected to the change were concerned they would have cause not to thank them, because they having been taught no other mode of earning a livelihood, and finding the mode they knew set on one side by the employment of a prime mover, would be at their wit's end for a means of subsistence, and would be experiencing those miseries which are caused by a state of transition. But in some way the men of the transition state must be relieved, and in the next generation, it no longer being possible to subsist by such wholly unintelligent labour, the energies of their descendants would be devoted to gaining a livelihood by some occupation more worthy of the mind of man.

Early prime movers, from their comparatively small size, probably did little more than thus relieve humanity; but when we come to consider the prime movers of the present day, by which we are enabled to contain within a single vessel and to apply to its propulsion 8,000 indicated horse-power, or an equivalent of the labour of nearly 50,000 men working at one time, we find that the prime mover has another and most important claim upon our interest: it enables us to attain results that it would be absolutely impossible to attain by any aggregation of human or other muscular effort, however brutally indifferent we might be to the misery of those who were engaged in that effort.

Excluding from our consideration light and even electricity, as not being, up to the present time, sources of power on which we rely in practice, there remain three principal groups into which our prime movers may be arranged, viz., those which work by the agency of wind, those which work by the agency of water, and those which work by the agency of heat. But some of these great groups are capable of division, and indeed demand division into various branches.

Water power may be due to the impact of water, as in some kinds of water-wheels, turbines, and hydraulic rams, or to water acting as a weight or pressure, as in other kinds of water-wheels, and in water-pressure engines; or to streams of water inducing currents, as in the case of the jet-pump, and of the "Trombe d'eau," or to its undulating movements, as in ocean waves. The ability of water to give out motive force may arise from falls, from the currents of rivers, from the tides, or, as has been said, from the oscillation of the waves.

Prime movers which utilise the force of the wind are few in number and in all cases act by impact.

As regards those prime movers which work by the aid of heat, we may have that heat developed by the combustion of fuel, and being so developed applied to heating water, raising steam, and working some of the numerous forms of steam-engines; or, as in the case of the Giffard injector, performing work by induced currents, by the flow of steam; or we may have the heat of fuel applied to vary the density of the air, and thus to obtain motion as by the smoke-jack; or the fuel may be employed to augment the bulk and the pressure of gases, as in the numerous caloric engines; or we may have heat and power developed in the combustion of gases, as in the forms of gas-engines; or in the combustion of explosives, as in gunpowder, dynamite, and other like materials, used not only for the purposes of artillery and of blasting, but for actuating prime movers in the ordinary sense of the word.

Again, we may have the heat of the sun applied through the agency of the expansion of gases or surfaces to the production of power, as in the sun-pumps of Solomon de Caus and of Belidor, and as in the sun-engine of Ericsson. Finally, we may have the sun's rays applied direct, as in the radiometer of Mr. Crookes.

A consideration of the foregoing heads, under which prime movers range themselves, will speedily bring us to the conclusion that the main centre of all mechanical force on this earth is the sun. If the prime movers be urged by water, that water has attained the elevation from which it falls, and thus gives out

power by reason of its having been evaporated and raised by the heat of the sun. If the power of the water be derived from the tidal influence, that influence is due to the joint action of the sun and the moon.

If the prime mover depend upon the wind for its force either directly, as in windmills, or indirectly, as in machines worked by the waves, then that wind is caused to blow by variations of temperature due to the action of the sun. If the prime mover depend upon light or upon solar heat, as in the case of the radiometer and of the sun engine, then the connection is obvious; but if the heat be due to combustion, then the fuel which supports that combustion is, after all, but the sun's rays stored up. If the fuel be, as is now sometimes the case, straw or cotton stalks, one feels that they have been the growth of the one season's effect of the sun's rays. If the fuel be wood, it is equally true that the wood is the growth of a few seasons' exercise of the sun's rays, but if it be the more potent and more general fuel coal, then, although the fact is not an obvious one, we know that coal also is merely the stored up result of many ages exercise of solar power.

And even in the case of electrical prime movers, these depend on the slow oxidation, that is burning, of metal which has been brought into the metallic or unburnt state from the burnt condition (or that of ore) by the aid of heat generated by the combustion of fuel.

The interesting lecture-room experiment with glass tubes charged with sulphide of calcium, or other analogous sulphides, makes visible to us the fact that the sun's rays may be stored up as light; but that they are as truly stored up (although not in the form of light) in the herb, the tree, and the coal we also now know; and we appreciate the far-seeing mind of George Stephenson who astonished his friend by announcing that a passing train was being driven by the sun. We know that Stephenson was right, and that the satirical Swift was wrong when he instanced as a type of folly the people of Laputa engaged in extracting sunbeams from cucumbers. The sunbeams were as surely in the cucumbers as they are in the sulphide of calcium tubes, but in the latter case they can be seen by the bodily eye, while in the former they demand the mind's eye of a Stephenson.

Although the sailing of ships and the winnowing of grain must from very early time have made it clear that the wind was capable of exercising a moving force, nevertheless, being an invisible agent, it is not one likely to strike the mind as being fit to give effect to a prime mover, and therefore it is not to be wondered at that prime movers actuated by water are those of which we first have any record, unless indeed the toy steam-engine of Hiero may be looked upon as a prime mover anterior to those urged by water. It would appear that in the reign of Augustus water-wheels were well known, for Vitruvius, writing at that time, speaks of them as common implements, but not so common as to have replaced the human turnspit, as we gather from his writings that the employment of men within a tread-wheel was still the most ordinary mode of obtaining a rotary force. It would seem, however, that water-wheels driven by the impact of the stream upon pallet boards were employed in the time of Augustus not merely to raise water by buckets placed about the circumference of the wheels, but also to drive mill-stones for grinding wheat, and Strabo states that a mill of this kind was in use at the palace of the King of Pontus.

(To be continued.)

SCIENTIFIC SERIALS

Poggendorff's Annalen der Physik und Chemie, No. 2, 1876.

—In the opening paper of this number Dr. König describes a series of researches in which he sought to study more closely the phenomena which occur when two sets of sound-waves meet in air; using sources of sound that were entirely isolated and could not act directly on each other, nor in common on a third body; he also chose sources that would give as simple tones as possible. The paper is in four parts, treating, severally, of primary beats and beat-tones, secondary beats and beat-tones, difference-tones and summation tones, and the nature of beats and their action, compared with the action of primary impulses. On the last head he finds, *inter alia*, that beat-tones cannot be explained by the cause of difference and summation tones, and that the audibility of beats depends only on the number and intensity of the primary tones, not at all on the width of the interval. The number of beats and primary impulses with which both may be

perceived as separate impulses is the same; so, too, with the number at which beats and primary impulses pass into a tone. Intermittences of a tone, as well as beats and primary impulses, may pass into a tone, and the periodic maxima of vibration of a tone, when in sufficient number. The beat tone formed by two primary tones must be always weaker than these, though separate beats are stronger than the tones forming them.—In M. Grottrian's researches on the constants of friction of some salt solutions, and their relations to galvanic conductivity, the method for ascertaining the constants was that of observing the oscillations of a suspended disc with attached magnet (under the influence of a neighbouring magnet) in air and in the liquid examined. The observed generally similar course of temperature coefficients for fluidity and galvanic conductivity, with change of concentration, leads the author to conclude that the overcoming of internal friction forms an essential part of the work done by a current in passage through an electrolyte. In the case of chloride of potassium, it is found that the increase of conductivity is almost exactly proportional to the percentage proportion (in the liquid); and M. Grottrian infers that the chemical changes he conceives generally to occur in chemical constitution of electrolytic molecules, on altering the concentration, do not occur here, but that with varied concentration, at the same temperature, the conductivity is only conditioned by the proportion of salt and the viscosity. With the numbers obtained in the experiments, it is possible to estimate for variously concentrated solutions of a salt, the temperatures for which the constants of friction have some determinate constant value; then to calculate the numbers for the conductivity at this temperature, and inquire according to what law these alter with the concentration. He thus shows that in the case of NaCl, KCl, CaCl₂, and BaCl₂, the concentration and the viscosity are the principal factors which determine the amount of the conductivity.—In the next paper M. Wiedemann makes some adverse criticism on the recent researches of some French physicists in the domain of magnetism.—M. Holtz shows that wire-net is very well suited for proving that in the interior of conducting surfaces there is no electrostatic action. In one experiment, a bell-shaped cover, made of the net, is brought down by an insulating handle on an insulated metallic disc connected with an electric machine, and on which stands a pith-ball electrometer. The two balls do not diverge in the least on working the machine; but if the bell be removed, they do so at once. He shows further, how such a bell is like a filter or sieve, holding back the electricity while it affords partial passage to gaseous matter or dust. If a metallic point connected to earth be brought near the electrified bell, the balls are moved, but do not diverge, &c.—Dr. Wichmann studies the properties of doubly-refracting garnets; and we note a paper by Dr. Sohncke on the figures eaten out by dissolving liquids on blocks of rock salt, and Exner's method for producing solution-figures.—There is an account of an interesting inquiry, lately conducted by Dr. W. Siemens, on the velocity of propagation of electricity in suspended wires.

Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. New Series. Part 2. Pp. 57 to 112.—This part contains several very interesting papers on various points of local geology. Some of the papers will be of use to a wide circle of readers, such as Mr. C. Bird's on the red beds at the base of the carboniferous limestone in the north-west of England, and Prof. Green's on the variations in thickness of the Silurian and Barmston coal seams in the southern part of the Yorkshire coal-field, and the probable manner in which these and similar changes have been produced. Mr. Bird considers it better to regard the red beds in question as basement beds of the carboniferous limestone than to attempt to draw any arbitrary line in a series whose members appear so closely linked together. Mr. Tiddeman's concise account of the work and problems of the settle Victoria cave exploration will also be welcome. Five good plates accompany this number of the *Proceedings*.

Bulletin de l'Académie Royale des Sciences, 2 ser. tome 40, No. 12.—M. van Beneden contributes a long paper divided into six chapters on the early stages of the embryological development of mammals. In 1874 M. Beneden published his paper, in which he showed that in Hydractinia spermatozooids are derived from the ectoderm and ova from the endoderm. He suggested that the same law probably applied to vertebrata. Observations supporting his view with regard to Coelenterata have been made by Koch and Fol, and M. Beneden has made embryological studies on the rabbit. A monograph with plates is promised. This paper is a *résumé*.—On the skeleton of a fossil whale in

the museum at Milan, by P. J. van Beneden. Following up the descriptions of Pachyacanthus and Aulocetus already given, M. Beneden proceeds to describe the fossil found in 1806 at Mount Pulgnasco, preserved in the Milan Museum, figured by Cortesi and described by Cuvier. The description is accompanied by a plate, and there are references to fossil whales in the museums at Turin, Florence, Bologna, Parma, and Pisa.—On the period of cold of the month of December, 1875, by M. E. Quetelet.—On the Devonian sandstones of Condroz, in the Basin of Theux, in the basin between Aix-la-Chapelle and Ath, and in the Boulonnais. The paper is illustrated with a folding plate giving nine coloured sections, and its scope is to show that the beds of the different localities mentioned have the same relative stratigraphical relations as at Condroz. All of the subdivisions show a remarkable constancy in their petrological and palæontological aspects.—On the description of some new birds, by M. Alph. Dubois. They belong to Cyanscitta and Icterus.—The theory of carnivorous and sensitive plants, by E. Morren. The article is a *résumé* of observations that have been made, and is well furnished with foot-notes. The index accompanies this number.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 18.—“Observations on Stratified Discharges by means of a Revolving Mirror, by William Spottiswoode, M.A., Treas. R.S.

In a paper published in Poggendorff's *Annalen*, Jubelband, p. 32, A. Wüllner has described a series of observations made, by means of a revolving mirror, upon the discharge of a large induction-coil through tubes containing ordinary atmospheric air at various degrees of pressure.

Wüllner's observations appear to have been directed rather to the nature of the coil discharge than to that of the stratifications.

For some time prior to the publication of the volume in question I had been engaged upon a series of experiments very similar in their general disposition, but with a somewhat different object in view, viz., the character and behaviour of the striæ; and of these, together with some recent additions, I now propose to offer a short account to the Society.

My general instrumental arrangements appear to have been similar to those of Wüllner; in fact, they could hardly have been very different. The tubes were attached to the coil in the usual way, and a contact-breaker of the ordinary form with its own electro-magnet was in the first instance used. For this and some other intermediate forms there was finally substituted a mercurial break (successfully arranged by my assistant, Mr. Ward), the plunger of which works on a cam attached to the axle of the mirror, so that the action of the contact-breaker is regulated by that of the mirror, instead of the reverse as in the former arrangement. With the broader tubes a slit was used; with the narrower this adjunct was less necessary; while with capillary tubes, such as are used for spectrum-analysis, it could be dispensed with altogether.

Striæ, as observed by the eye, have been divided into two classes, viz., the flake-like, and the flocculent or cloudy. Of the former, those produced in hydrogen tubes may be taken as a type; of the latter, those produced in carbonic tubes. But upon examining some tubes especially selected for the purpose, it was found that, while to this apparent a real difference corresponds, a fundamental feature of the striæ, underlying both, was brought out.

The feature in question was this: that the striæ, at whatever points produced, always have during the period of their existence a motion along the tube in a direction from the negative towards the positive terminal. This motion, which I have called for convenience the proper motion of the striæ, is for given circumstances of tube and current generally uniform; and its variations in velocity are at all times confined within very narrow limits. The proper motion in this sense appertains, strictly speaking, to the flake-like striæ only. The apparent proper motion of the flocculent striæ is, on the contrary, variable not only in velocity, but also in direction; and on further examination it turns out that the flocculent striæ are themselves compounded of the flake-like, which latter I have on that account called elementary striæ.

Elementary striæ are in general produced at regular intervals along the tube. The series extends from the positive terminal in the direction of the negative to a distance depending upon the actual circumstances of the tube and current. The length of